SHORTER ARTICLES AND DISCUSSION

ANOTHER HYPOTHESIS TO ACCOUNT FOR DR. SWINGLE'S EXPERIMENTS WITH CITRUS

THE results of the cross-breeding experiments with forms of *Citrus* by Walter Swingle have given rise to quite a number of different hypotheses, to account for the facts observed.

The facts are simply these. All the different forms of *Citrus* used in the experiments, *Citrus trifoliata,* the lemon, orange and other citrous fruits have, so far, proved to reproduce their own type through seed.

Nevertheless, the plants raised from one single cross are exceedingly different among themselves. And yet, all these new forms, for so far as tested, have proved truly to reproduce their own kind only, if sown.

The theories offered to account for these facts are rather complex. So far, we have not seen the simple hypothesis which we want to add to the others.

The fact, that the F_1 from almost every cross between types of *Citrus* is multiform, can only be accounted for on the assumption, that the parent plants are impure (heterozygous) for a number of genes. The difficult question is this: how can a tree, impure for a number of genes, produce seed which always only reproduces the type? We know, that if a plant reproduces itself by an asexual method, all its daughter plants are pure for those genes in respect to which it was pure, impure for those genes for which it was impure. Is it possible that in these trees the seeds normally produced are not derived from a union between two normal gametes? In *Citrus,* with its adventitious embryos, this is very well possible. If the forms of *Citrus* used by Dr. Swingle are self-sterile, the seeds normally produced by these trees, are not produced by the union of two gametes, but as buds, asexually.

This hypothesis, that the *Citrus* used are self-sterile, and that the seeds normally produced, are produced asexually, fully accounts for all the facts. All the daughter plants from uncrossed seeds are genotypically identical with the mother plant, as in all clones. On pollenization by another tree, normal seeds are produced, each the result of the union of two real gametes.

These seeds contain different combinations of the genes, for which the parent plants are impure, as normally. The F_1 generation for this reason becomes as diverse as such generations always are, if the parents are impure for numerous genes.

But these daughter plants, although impure for a number of genes, can, because of their self-sterility, in their turn only produce seed asexually and therefore their offspring will be like themselves.

It should not be difficult to test our hypothesis. It seems easier to find out, whether the seeds produced without crossing in *Citrus* contain the embryo formed by fertilization of the embryo sac, or embryos formed adventitiously by the adjacent tissue, than to test any of the other theories, which assume a peculiar behavior of the chromosomes.

Our hypothesis, that a variable F_1, of only true-breeding plants (from the union of two true-breeding forms), results from habitual self-sterility and asexual production of seed, with real fertilization in the case of a cross taking place, not only accounts for the facts found by Swingle, but also for those found by Rosen with *Erophila verna*. These facts were somewhat different. The F_1 plants were all identical, and somewhat intermediate. They gave rise to a variable F_2 generation of which all the plants bred true to their type. These facts can be explained on the assumption, that *Erophila verna* is self-sterile, and that, in the absence of cross-fertilization, unfertilized egg-cells develop parthenogenetically. Such F_1 plants, which are impure for a number of genes, should therefore produce as many different kinds of F_2 plants, as there are female gametes produced, and in the same proportions. In the case of such a plant being impure for two genes, we should expect it to produce plants of the four different types, not in the usual proportion of 9:3:3:1, but in equal proportions, 1:1:1:1. The F_2 plants from such seed could only be pure for all the genes present.

It would be possible in *Erophila verna* to find out whether F_1 plants, impure for two genes, produced daughter plants of the four kinds, *AB*, *Ab*, *aB*, and *ab*, in the proportion of 9:3:3:1, or in proportion 1:1:1:1, and thus to test our hypothesis.

To find out, whether it is possible, that a plant, impure for a number of genes, produces a variable F_2 generation of only completely homozygous plants, we have begun a series of experiments with squashes. Some hybrid plants have not produced a

single fruit from carefully sealed female buds, others have given plenty of empty fruit, but some hybrids have produced several fruits, full of viable seed. If this seed is formed by the parthenogenetic development of unfertilized normal egg-cells, as we have reason to believe, we expect to raise a variable F_2 generation of exclusively homozygous plants. If these seeds have developed by apogamy, or any other asexual process, we expect to obtain a second generation consisting exclusively of plants like the original hybrids. Thus we will have a non-cytological test to decide between apogamy and true parthenogenesis.

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